WILDLIFE CONSERVATION SOCIETY

THE STATUS OF THE AMUR TIGER AND SELECTED UNGULATES IN THE RUSSIAN FAR EAST: A 2005 WINTER SURVEY

AN INTERIM REPORT TO

21ST CENTURY TIGER

FROM THE

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INTRODUCTION

In 1996-1996 a full range survey of Amur tigers was conducted, indicating the existence of 330-371 adult tigers, and some 100 young in the Russian Far East. Since that time conservation of this subspecies has become a key priority for regional and federal ecological policies. Although not immediately threatened with extinction, the Amur tiger's future has been cause for serious concern. With the exceptions of zapovedniks (reserves) and other protected areas, most forestlands within the range of tigers have been subject to intensive legal and illegal logging operations. Ungulate numbers have decreased regionally, resulting in conflicts between hunters and tigers. New legislation that may privatize Russian Forest Service lands (GOSLESFUND) could prove to be an even more serious threat to tigers and other rare species dependent on forest habitats. And, results from the first six years of the Amur Tiger Monitoring Program suggest changes are occurring in the Amur tiger population: tiger track densities are decreasing, and litter production is also decreasing.

Based on recommendations of the National Strategy, and the final resolution of the 2003 Khabarovsk Conference on Tiger Conservation, this project was designed to conduct a full range survey of Amur tigers in the Russian Far East to determine the range and status of the entire population. Just as importantly, the survey was designed to provide an assessment of prey abundance across tiger range. With assistance from 21st Century Tiger, during the winter of 2005 this project was successfully implemented. This report describes how the survey was conducted. Analysis of data is ongoing; a final report on the survey findings will be available later this year.

OBJECTIVES OF THE 2005 FULL RANGE TIGER AND PREY SURVEY

1. Determine the present range of tigers in the Russian Far East.
2. Use a standardized estimate of track density as an indicator of tiger abundance across areas in the Russian Far East.
3. Develop a standardized algorithm to convert track data into an estimate of tiger abundance across its range.
4. Use expert assessment of actual tiger numbers as a third indicator of population trends over time.
5. Record presence of tigresses with young cubs across the range of tigers in order to estimate reproduction rates, identify areas of high/low productivity, and determine changes in reproduction over time.
6. Estimate prey abundance (both relative and absolute) across tiger range.
7. Record information on tiger mortality across its range.
8. Record changes in habitat quality.

PROGRESS TO DATE (BY OBJECTIVE)

Objectives 1-2, 4-5

All four of the above objectives are dependent on collecting data on track distribution and abundance across the entire range of tigers in Russia. To this end, we divided the entire range of tigers into ten regions, and assigned a coordinator with responsibility for each region (see Table 1, Figure 1).

Unfortunately, a series of tragedies occurred since the inception of the survey, requiring readjustments in the implementation of the survey itself. First, in September 2004, Vladimir Abramov, one of the prominent tiger biologists of the region and an employee of the *Ussuriski Zapovednik*, died after a heart operation. Two weeks later, Dimitri Pikunov, another eminent biologist and overall survey coordinator for *Primorski Krai*, suffered a massive heart attack, but thankfully survived. Finally, Victor Korkisko, a leopard biologist in *Kedrovya Pad* responsible for our tiger survey efforts in SW *Primorye*, died of lung cancer in January 2005. Although these losses were difficult for all of us, we believed each of these dedicated individuals would have wanted the survey to continue, and for it to be carried out in the best way possible. Consequently, we assigned graduate student Ivan Seryodkin—a student of Pikunov's and a long-time worker on both WCS's Siberian Tiger Project and WCS's Kamchatka Bear Project—to take primary responsibility for *Pojarski Raion* (including the Bikin River, one of the most remote and difficult places to work in tiger territory), and to assist V. Litvinov in the region surrounding *Ussuriski Zapovednik* (formerly the responsibility of Vladimir Abramov). Litvinov worked with Abramov for many years, and has a deep understanding of the annual tiger monitoring program in the region. Together with Seryodkin, they have done an admirable job of filling in void left by the late Abramov. While Pikunov was in the hospital, Dale Miquelle filled in as coordinator for *Primorski Krai*. Dimitri Pikunov recovered quickly from his heart attack, and although he had to allocate *Pojarski Raion* to Seryodkin, he retained responsibility for the northern portion of SW *Primorye*, and took over the neighboring territory (which had been the responsibility of V. Korkishko). Thus, despite our losses, survey work continued without serious setbacks.

Each coordinator was responsible for dividing each region into a set of sampling cells, which were intended to average 100-150 km^2. Within each sampling cell, we intended to collect three types of data:

1. To determine if tigers occur in the cell, an individual (or group of individuals) were assigned the task of reporting tracks of tigers—as well as other carnivores—during the entire winter.
2. To delineate the presence of tigers to estimate numbers, a survey route of at least 10 km (represented survey intensity of 1 km/10km^2) was placed within the cell to maximize probability of encountering tiger sign.

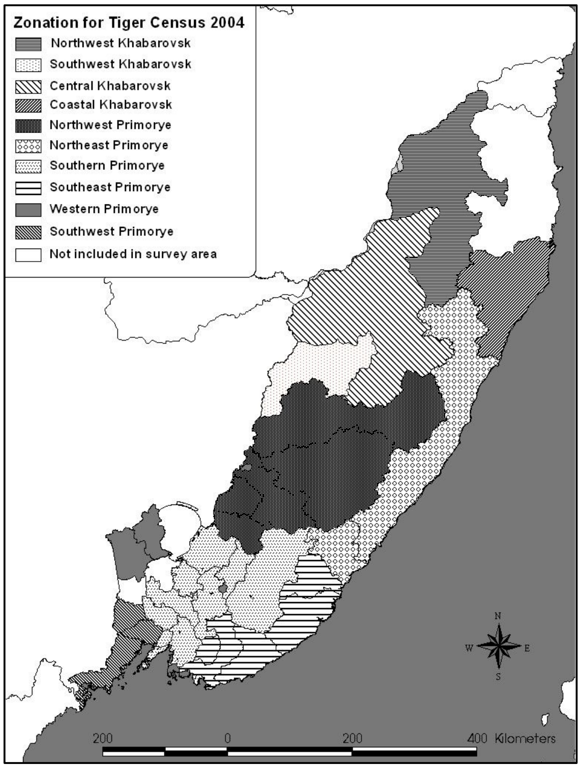

Figure 1. *Raions* (counties) to be surveyed for tigers in the 2005 winter survey

Table 1. Division of Tiger habitat in Russian Far East by Raion (county) and coordinators, for 2005 Amur tiger survey				
Krai (Province)		Region	Raion (county)	Coordinator
Primorye	1	Southwest	Khasanski	Korkishko/Pikunov
			Nadesdenski	Pikunov
			Ussuriski (western half)	Litvinov/Seryodkin
	2	West	Pogranichniy	Nikolaev
			Khankaiski	Nikolaev
	3	Southcentral	Spasski	Yudin
			Chernogovski	Yudin
			Mikhailovski	Litvinov/Seryodkin
			Vladivostok (outer city limits)	Litvinov/Seryodkin
			Shkotovski	Litvinov/Seryodkin
			Ussuriski (eastern half)	Litvinov/Seryodkin
			Anuchinski	Litvinov/Seryodkin
			Chuguevski	Gaponov
			Yakolevski	Gaponov
	4	Southeast	Kaverlovski	Aramilev
			Olginski	Aramilev
			Partizanski	Salkina
			Partizanski City	Salkina
			Lazovski	Salkina
	5	Northeast	Terneiski	Smirnov
			Dalnegorski	Kostyria
	6	Northwest	Pojarski	Seryodkin
			Krasnearmenski	Fomenko
			Dalnerechenski	Nikolaev
			Lesozavodski	Nikolaev
			Kirovski	Nikolaev
Khabarovsk	7	Southwest	Bikinski	Dunishenko
			Vyasemski	Dunishenko
	8	Central	in-the-name-of Lazo	Dunishenko
			Khabarovski	Dunishenko
	9	Northwest	Komsomolski	Dunishenko
			Nanaiski	Dunishenko
	10	East (Coastal)	Sovgavanski	Dunishenko

The first phase of the survey (planning, contacting fieldworkers, and laying out the design of the survey) took place from late summer through November of 2004. The first data collection commenced with the first snows, which in many areas occurred in November of 2004. The simultaneous surveys took place across the entire area during February 10-15, 2005. Collection of data from fieldworkers took the remaining time in February, and all of March, as each field datasheet had to be reviewed with each fieldworker. We photocopied each field "diary" to ensure no data were lost, and returned copies to coordinators, who will develop expert assessments of tiger numbers.

To date, we do not have a final count of the number of sampling units, number of transects, or transect lengths that were covered during the survey, as data input into a GIS system is ongoing, and will be ongoing into the fall. However, we do have crude estimates of these values (Table 2), based on mid-winter projections done by our coordinators. The total area of all *raions* where sampling occurred was nearly 200,000 km^2. However, actual tiger habitat represents probably less than 150,000 km^2. We have established approximately 1,040 sampling cells, which, if averaging 125 km^2 each, represent a total area of approximately 130,000 km^2. Exact values will be forthcoming, but these rough estimates provide an indication of the territory covered. Approximately 80% of the land of these sample cells was covered with "all winter" surveys (i.e. fieldworkers were present for substantial periods of time) to estimate the presence of tigers in them. For the remaining unsampled cells, we will have to derive probability estimates for tiger presence if tracks were not recorded during the simultaneous survey.

Within each cell, there exists at least one (and occasionally two) transect placed to maximize probability of encountering tiger signs (Table 2), as well as one to estimate ungulate density (see below), which will also be used to record presence of tigers. Thus, we are projecting that over 2,000 survey routes will have been traveled during the tiger census efforts. Assuming each route is a minimum of 10 km—as required in our survey protocols—well over 20,000 km of survey routes will have been covered by the survey. Presently, coordinators are summarizing data, writing reports for their respective regions, and deriving expert estimates of the number of tigers in their region.

In past full range surveys, the exact criteria for distinguishing individual tigers was never specifically delineated. Because there has been no rigorous, standardized method to interpret data, results of expert assessments are difficult to compare unless the same experts conduct subsequent surveys. We believe that expert assessments provide a valuable means of assessing tiger abundance, and provide a linkage to the long history of tiger survey efforts in Russia, which began as early as 1940. There is a need to retain that linkage, yet provide better defined criteria for deriving estimates of abundance. The parameters for such an algorithm have been largely defined already. During the data analysis phase of the last survey, Matyushkin et al (1996) developed a set of hard and soft criteria to assist in allocating tracks to one or more individual tigers. These criteria, although referred to, were never published, and although they were used as a guide in interpreting track data, were never strictly applied to the data set. We have used new information derived both from WCS's Siberian Tiger Project and elsewhere, to formalize these criteria, which will act as a guide for developing expert assessments for the 2005 survey and as a guide for developing a standardized algorithm for estimating minimum number of tigers present (see Appendix 1).

Objective 3: Develop a Standardized Algorithm to Convert Track Data into an Estimate of Tiger Abundance across Its Range

Even with the standardized criteria derived above, there are problems with expert assessments deriving reliable estimates of tiger abundance. Changes in personnel bring unknown and immeasurable changes to the results. Therefore, the development of a standardized mechanism for interpreting abundance and distribution of tracks that is compatible with expert assessment techniques will provide structure and standardization to the process, and will allow retrospective analyses for those previous surveys that exist in a GIS database (presently, only the 1996 tiger survey). The parameters for such an algorithm are largely defined by the parameters established for expert assessments (Appendix 1). The advantages of applying such a standardized set of criteria are that standardized criteria are not subject to individual interpretation, and therefore data gathered across the entire region can be processed in the same way, and direct comparisons of tiger numbers are possible. Also, using "strict" and "relaxed" criteria in the expert assessment results in a range of values, approaching something like an assessment of error, although it is difficult to assess sources of error. Using a computerized approach in varying key criteria, it is possible to conduct a sensitivity analysis that can specifically define the impact of errors in measurement or the changes (errors) in the criteria used. Such an analysis provides a mechanism to determine the likely range of errors that can be derived from the interpretation of track data.

УЧЕТ АМУРСКОГО ТИГРА 2004/2005

Table 2. Sampling effort for Amur Tiger Survey-2005

	Aramilev	Litvinov	Pikunov	Korkishko	Nikolaev	Salkina	Yudin	Gapanov	Kostyria	Fomenko	Smirnov	SABZ	Duni-shenko	Total
Area (км^2)	10601	11546	25947	4209	23412	10257	6090	14672	5382	20480	27245	4000	33643	197483
# survey cells	85	44	150	12	89	90	23	110	45	120	55	7	210	1 040
Data collection during entire winter	85	44	150	12	65	96	23	110	26	120		5	100	836
Simultaneous count- tiger survey routes	85	56	150	13	89	96	23	110	45	100	39	61	210	1 077
Simultaneous count- ungulate survey routes	85	44	150	12	89	96	23	110	45	100	39		210	1 003
Control routes	10	8	10	5	10	10		10	10	5				
Total survey route density	**1.60**	**0.87**	**1.16**	**0.59**	**0.76**	**1.87**	**0.76**	**1.50**	**1.67**	**0.98**	**0.29**	**1.53**	**1.25**	**1.14**

Table 3. Sensitivity analysis of 1996 Amur tiger winter survey, varying maximum diameter of home range, daily travel distance, and ability to differentiate animals by difference in track size. Grey vertical lines represent values used in 1996 and 2005 to differentia

Maximum diameter home range (km)		Daily travel distance (km)			Pad size range classes (ability to differentiate individuals based on pad size difference) (cm)																			
Female	Male	Female with cubs	Adult female	Adult male	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2
					0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2
3.15	3.85	0.05	0.9	1.1	730	730	721	721	721	720	719	709	709	709	708	708	702	702	702	702	701	692	692	691
4.27	5.25	0.315	1.22	1.5	696	695	682	682	682	679	678	666	666	666	665	665	656	656	656	655	654	642	642	641
5.39	6.65	0.58	1.54	1.9	662	661	644	644	644	639	638	622	622	622	621	621	606	606	605	604	603	583	583	583
6.51	8.05	0.845	1.86	2.3	634	633	613	613	613	609	608	588	588	587	584	583	571	571	570	569	568	545	545	545
7.63	9.45	1.11	2.18	2.7	609	608	585	585	585	580	579	558	558	557	554	554	540	540	539	538	537	514	514	513
8.75	10.85	1.375	2.5	3.1	586	585	555	555	554	551	549	526	525	525	523	523	507	507	504	503	502	474	473	472
9.87	12.25	1.64	2.82	3.5	570	569	535	535	535	530	529	505	504	504	502	502	487	487	484	481	480	453	453	452
10.99	13.65	1.905	3.14	3.9	555	554	517	517	518	510	509	481	480	480	478	477	456	456	453	449	449	423	422	421
12.11	15.05	2.17	3.46	4.3	541	540	503	503	504	494	494	468	466	465	465	463	441	441	439	438	436	404	402	402
13.23	16.45	2.435	3.78	4.7	527	525	489	488	487	477	476	448	447	446	442	442	423	424	422	421	420	387	385	385
14.35	17.85	2.7	4.1	5.1	519	517	478	477	476	466	465	435	434	434	431	429	412	411	409	407	407	374	372	372
15.47	19.25	2.965	4.42	5.5	507	505	462	460	459	451	450	419	418	417	411	410	396	395	392	391	391	360	358	357
16.59	20.65	3.23	4.74	5.9	501	498	449	448	447	439	438	408	407	406	402	402	385	384	381	378	375	346	346	346
17.71	22.05	3.495	5.06	6.3	494	492	434	433	431	425	423	393	391	391	388	388	367	367	365	362	359	330	330	330
18.83	23.45	3.76	5.38	6.7	492	489	428	428	425	418	416	385	383	383	381	382	360	360	357	353	352	323	323	322
19.95	24.85	4.025	5.7	7.1	484	482	422	422	418	413	412	373	372	372	368	367	344	344	342	340	338	311	311	311
21.07	26.25	4.29	6.02	7.5	474	470	411	408	406	400	399	363	361	360	357	356	336	336	333	333	333	309	308	307
22.19	27.65	4.555	6.34	7.9	467	464	403	400	398	392	390	355	353	352	347	346	329	329	327	327	327	303	302	301
23.31	29.05	4.82	6.66	8.3	462	459	397	395	391	386	384	348	344	343	340	338	321	321	319	318	319	298	297	296
24.43	30.45	5.085	6.98	8.7	459	455	392	390	388	381	381	341	336	337	333	333	313	313	309	310	309	286	285	284
25.55	31.85	5.35	7.3	9.1	453	449	384	381	381	375	372	335	331	331	326	325	308	307	305	304	304	280	280	278
26.67	33.25	5.615	7.62	9.5	448	445	377	373	371	367	367	325	321	321	315	314	299	301	298	297	296	275	273	272
27.79	34.65	5.88	7.94	9.9	440	436	368	365	363	360	358	317	314	315	309	308	294	292	291	291	290	264	263	262
28.91	36.05	6.145	8.26	10.3	433	429	365	361	360	357	355	313	310	311	305	304	289	287	287	284	285	261	259	259
30.03	37.45	6.41	8.58	10.7	421	417	356	352	351	349	347	307	305	306	299	299	281	280	278	276	275	255	253	251
31.15	38.85	6.675	8.9	11.1	416	413	353	349	348	343	341	305	300	300	295	294	271	270	268	267	266	250	249	247
32.27	40.25	6.94	9.22	11.5	414	410	349	345	343	337	335	300	299	300	295	294	271	271	269	267	266	246	245	243
33.39	41.65	7.205	9.54	11.9	409	405	345	342	339	333	331	294	293	295	290	289	266	264	262	262	261	239	237	237
34.51	43.05	7.47	9.86	12.3	404	401	342	341	339	332	328	291	289	291	286	285	265	262	260	261	259	237	235	234
35.63	44.45	7.735	10.18	12.7	399	395	341	339	336	330	326	287	285	286	282	282	264	262	259	259	259	235	234	232
36.75	45.85	8	10.5	13.1	395	392	336	334	330	324	323	279	278	278	276	276	257	256	253	254	254	229	227	226

Based on the criteria delineated in Appendix 1, we have developed an algorithm to provide an estimate of minimum number of tigers likely to occur in an area. We have also conducted sensitivity analyses using both long-term monitoring data from our Amur Tiger Monitoring Program and from the 1996 Amur tiger survey. In Table 3, we provide an example of the sensitivity analysis for the 1996 survey. By comparing estimates of error in measuring track size and errors in measuring daily travel distance, we are able to derive a range of potential minimum estimates for tiger abundance. Using the standard criteria that will be applied to the 2005 survey, minimum abundance of adult tigers was likely between 299 and 325. The reported values for adult tigers in 1996 was 330-371. These results reinforce each other, as the algorithm is intended to represent a minimum estimate.

Interestingly, further sensitivity analyses suggest that errors associated with measurement of track size do not influence results of the estimate as much as changes in daily travel distance do (Figure 2). Despite relative major differences in estimates of track size error (ranging from 0.5 to 2.0 cm), estimates of tiger abundance for any single travel distance remain tightly clustered. However, changes in daily travel distance—especially in the range of values that appear reasonable for adult tigresses (5-15 km)—have very large effects on estimates of number of tigers present.

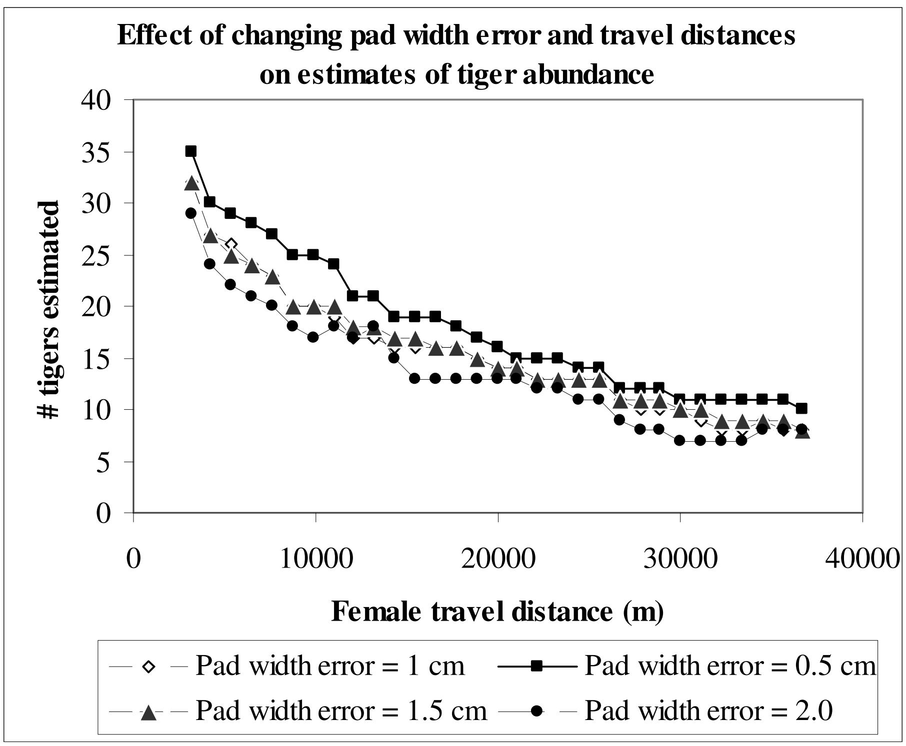

Figure 2. Sensitivity analysis of algorithm to estimate minimum numbers of tigers. Effect of changing pad width error and daily travel distances for adult female tigers.

These results suggest that errors in estimating track size, usually a major concern among biologists conducting tiger surveys, may not be as important as other variables, such as daily travel distance, in affecting the final survey results.

Objective 6: Estimate Prey Abundance (Relative and Absolute) Across Tiger Range

Because prey distribution and abundance is considered a key component determining tiger distribution and abundance, and because there is great concern over the impact of both tigers and hunters on prey populations, a good assessment of ungulates numbers is considered an essential component of this survey. To be effective, a methodology must be both economically and logistically feasible, must have a good survey design, and must ensure adequate statistical sampling. We considered the following species in our survey design:

- Red deer (*Cervus elaphus*)
- Wild boar (*Sus scrofa*)
- Roe deer (*Capreolus capreolus*)
- Sika deer (*Cervus Nippon*)

Other ungulates in the area, e.g. Manchurian moose (*Alces alces cameloides*), musk deer (*Mochus moschiferus*), and goral (*Nemorhaedus caudatus*), make up a small and relatively insignificant portion of prey for tigers (Zhivotchenko 1981, Yudakov and Nikolaev. 1987, Matyushkin 1992, Miquelle et al. 1999,) and are not considered in our survey methodology.

Distribution of prey can be derived in two ways. First, because tracks will be geo-referenced, creating a small "buffer" around each track and aggregating all would provide a preliminary assessment of distribution. More reliable would be an analysis of species distributions in relation to habitat types within specific survey zones (Figure 3).

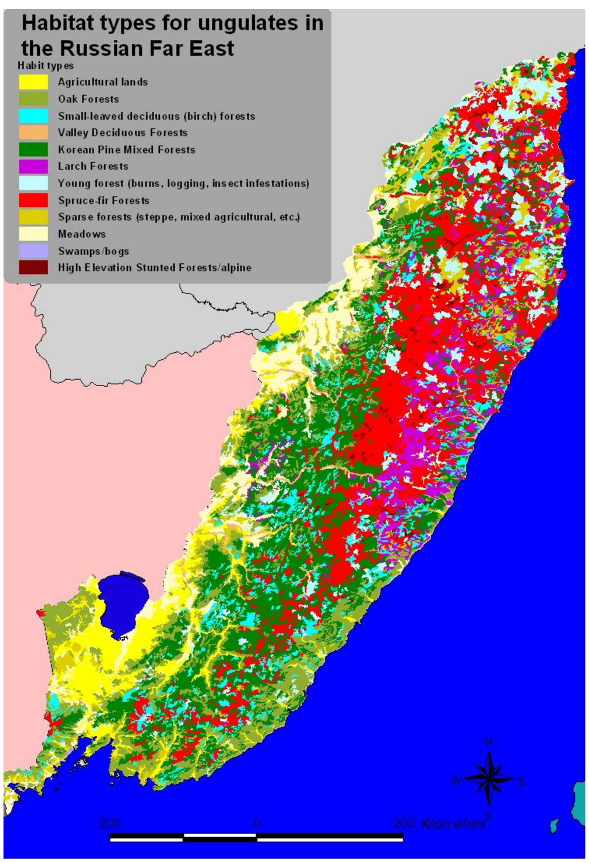

Figure 3. A simplified habitat map developed from Landsat satellite images.

Mapping of ungulate distribution can then be extrapolated by the distribution of preferred habitat types.

Estimation of ungulate abundance is more difficult. Unlike the sampling design for tigers, it is impossible to attempt a complete survey of ungulates and it will therefore be necessary to draw conclusions based on a sampling of the entire population. The objective of a good survey sampling design is to maximize the quality of information obtained (i.e., minimize the error) with the most effective use of existing resources. Stratification can be employed to increase precision (reduce variation) and increase the amount of information obtained (efficiency) per unit effort in a sampling design.

Three general approaches to estimate prey abundance based on tracks have been derived (the following text on estimates of ungulate distribution is largely derived from Stephens et al., in prep.). The first and simplest method for estimating density from track encounters is an empirical correction factor, which is used to translate combined encounter rates of deer tracks into estimates of deer density and associated confidence intervals. This correction factor was derived by regressing observed numbers of deer within a plot (determined by expert assessment of tracks entering and leaving a plot) on numbers of tracks encountered when the plot perimeter was walked (Gerow et al., 2005). The second method to estimate ungulate densities from survey data uses a formula known variously as the Formozov (Mirutenko, 1986) or Formozov–Malyashev–Pereleshin formula (Kuzyakin, 1983). All of these authors were involved in prompting the derivation of the formula but it was perhaps most comprehensively derived by Chelintsev (1995). This formula is based on probabilistic encounters between randomly placed and orientated animal paths and surveyed routes (hereafter, we refer to it as the FMP formula). The third approach that can be used to assess the relationship between track encounters and population density is simulation modeling. Using empirical records of movement patterns, large numbers of simple simulations can be performed to provide a relationship between track encounter rates and densities of paths. Simulation modeling is a computerized version of graphical techniques that have a long history in Russia (e.g. Kuzyakin, 1983).

The second and third of these methods require, respectively, estimates of daily travel distance and actual daily travel routes. Therefore, in preparation for this survey, over the past three years we have conducted relatively intensive studies of daily travel distances in two areas, *Sikhote-Alin Zapovednik* and *Lazovski Zapovednik* (Table 4).

Table 4. 24-hour movement data collected for analysis.

	Number of daily travel distances measured from:		
Species	Lazovski Zapovednik	SAZ	Total # measured
Red deer	7	90	97
Roe deer	9	62	71
Sika deer	14	10	24
Wild boar	3	85	88
Total	33	247	280

Analyses of these data demonstrate that characteristics of daily travel distances vary greatly by region (Figure 4). Although further analyses suggest that using daily travel distance and the FMP formula may be the most direct and effective way to estimate ungulate abundance, accurate estimates of daily travel distance are essential. Since data suggests that daily travel distances vary by region and snow depth, use of this approach would require vast resources to simultaneously measure travel distance and track abundance. Accurate estimates of daily travel distance have been a recurring problem in estimating ungulate abundance across Russia, despite the potential for this approach.

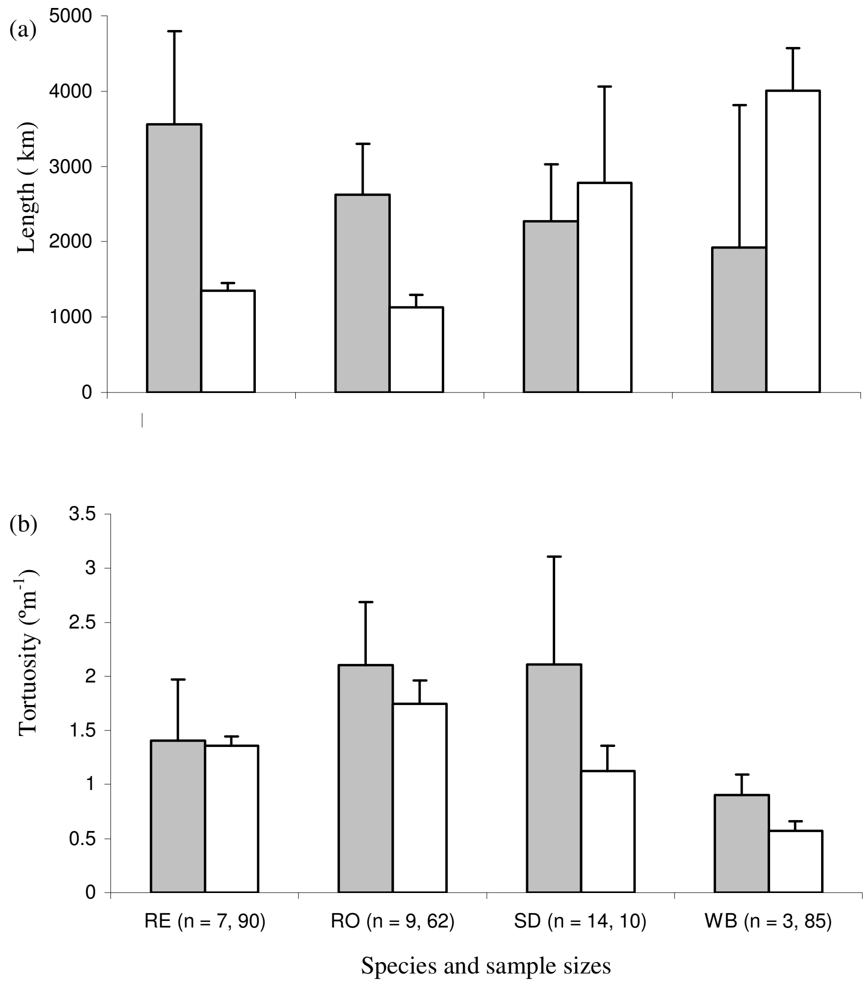

Figure 4. Mean length (a) and tortuosity (b) for paths of the four different species in *Lazovski Zapovednik* (filled bars) and *Sikhote-Alin Zapovednik* (open bars): RE, red deer; RO, roe deer; SD, sika deer; WB, wild boar. Error bars show 95% confidence interval. Figures in parentheses show sample sizes for *Lazovski* and *Sikhote-Alin Zapovednik*, respectively.

Because estimates of daily travel distance are so difficult to achieve, we opted to use the first method, deriving an empirical correction factor used to translate encounter rates of tracks by species into estimates of density and associated confidence intervals. To develop this relationship, simultaneously with the implementation of the tiger survey, we collected two types of data to estimate ungulate abundance:

1. To estimate track abundance, routes developed to ascertain the presence of tigers probably provide a biased estimate of ungulate abundance. Most tiger survey routes are in valley bottoms, following trails and established movement corridors. Valley bottoms may contain relatively high or low numbers of ungulates, depending on snow conditions. To provide a better estimate of ungulate numbers, a second route also covered during the simultaneous survey was placed in each cell, in order to represent the full range of habitats within the cell. Information on tigers and other carnivores was also reported along these routes, but we can use data on ungulate numbers first, then compare these estimates to "tiger" routes, and if there is a significant difference, use only "ungulate" routes to estimate density of ungulate tracks.

2. To derive a relationship between track abundance and animal abundance, 100 plots were laid out across the full range of habitat types in *Primorye* (60 plots) and *Khabarovsk* (40 plots). On each plot, tracks were counted on the periphery of the plot, and then a drive count was conducted to determine the exact number of ungulates within the plot. These two values (track count and animal count) will then be used to derive species-specific relationships that can later be used to estimate animal abundance based on track abundance. These analyses are ongoing.

   As an example, in 2002 we conducted a pilot study of the relationship of track abundance and ungulate abundance on 60 plots that averaged 10.5 km^2 in southeast *Primorski Krai*. The results suggest that there are reasonably good correlations between track density and animal density for the three deer species (Figures 5 a-c). The relationship for wild boar was poor (Figure 5d), and will need additional work to determine whether a similar relationship can be derived.

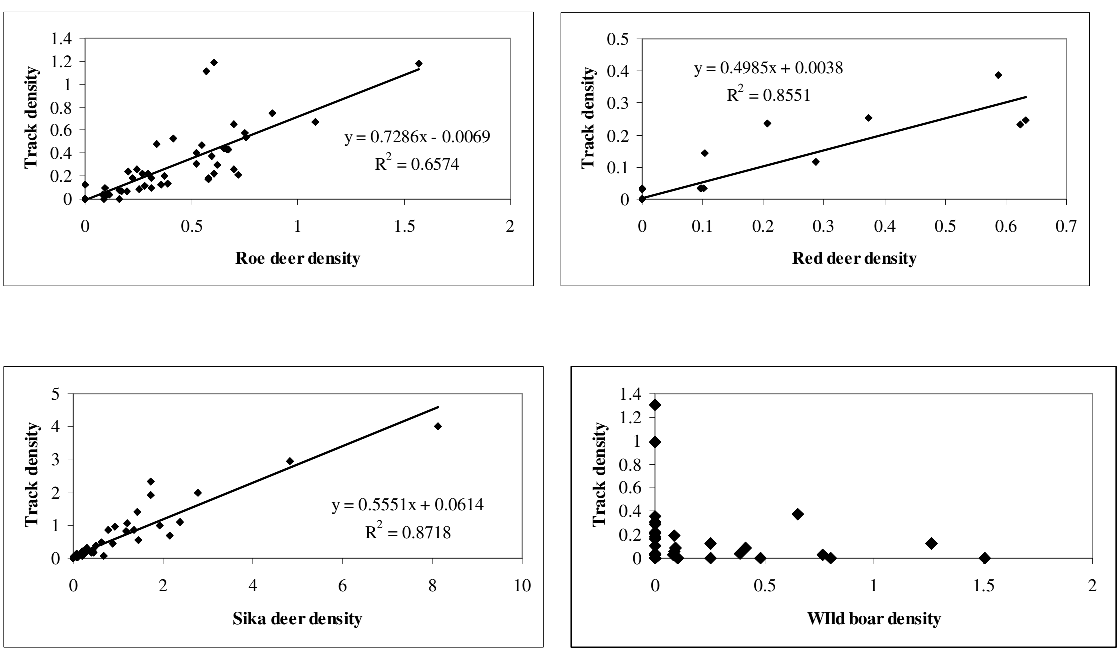

Figure 5a-d. Relationship between animal density and track density for (a) roe deer (b) red deer (c) sika deer and (d) wild boar, based on 60 plots sampled in southeast *Primorye*, 2002.

Objective 7: Record Information on Tiger Mortality Across Its Range

A questionnaire distributed to all fieldworkers included a request on information about tiger mortalities. These data will no doubt be biased towards human-caused mortality, but can still provide some valuable insight into the motives of the killings carried out by humans (e.g., whether accidentally or intentionally, for profit, or in retaliation for depredation), and can provide a geographic indication of where mortality is occurring.

Objective 8: Record Changes in Habitat Quality

We have requested that all coordinators develop maps representing quality and marginal tiger habitat in the region they are responsible for surveying. We will use this data in combination with resource selection functions, in order to identify quality tiger habitat, identify potential tiger habitat, and compare this information to survey data on distribution and relative abundance of tigers. By having coordinators map tiger habitat, we will be in a position to engage in the political process of developing an official map of tiger habitat, which could be included in the environmental impact statements that must be done for any human activities (such as logging, mining, etc.).

DATA STORAGE

A key component of planning for a survey is the development of a reliable means of storing and analyzing data. Our experience indicates that if original raw data is not created in an electronic, standardized format, it is often either lost or unrecoverable after two to four years, at which point it becomes impossible to conduct future analyses or comparisons. Therefore, it is essential that an electronic version of the original data is created and stored properly. We have significant experience in creating geographically referenced databases from our work with the Amur Tiger Monitoring Program, previous leopard surveys, and the 1996 tiger survey.

The format developed for the previous leopard surveys are forming the basis for this new data set. WCS and TIGRIS invested substantial finances and energy into developing this spatially explicit database for the Russian Far East. The creation of a GIS database in a standardized format ensures long-term protection of the data, and at the same time provide relatively easy access for analysis. We already developed a database for the 1996 survey, as well as a wealth of other relative data layers (habitat types, land use coverages, settlements, roads, river systems, etc.). A GIS database for the 2005 survey is being created in Microsoft ACCESS, and linked to a GIS database accessible via ArcView (ESRI Corp.). This database will contain all data collected by fieldworkers on every tiger track, ungulate track, individual tiger, tiger deaths, route information, and count unit. The ArcView project will likely exist in two scales: 1) 1:500,000 for general reference to the entire range of tigers; and 2) 1:100,000, which is the scale used for recording and entering data on specific count units.

We expect to have the final report prepared on this project by December 2005.

APPENDIX 1

STANDARIZED CRITERIA USED TO INTERPRET TIGER TRACK DATA TO DERIVE EXPERT ASSESSMENTS OF TIGER NUMBERS IN THE RUSSIAN FAR EAST (first derived by E. N. Matyushkin et al.,1996 unpublished. Updated and revised by D.G. Miquelle et al., 2005)

INTRODUCTION

These criteria are to be used by all coordinators to provide an expert assessment of number of tigers for the 2005 Amur tiger survey. Please note that to provide standardization in conducting expert assessments, all coordinators must use these criteria in defining the number of tigers in the area you are responsible for.

<u>Use of simultaneous and "all winter" data</u>: First, conduct an analysis of track data from the simultaneous survey, using the criteria as defined below, and then include additional track data from the "all winter" data set. Each track from both the simultaneous survey and all winter field diaries should be either assigned to a specific tiger or labeled as "not included." The forms for reporting these tracks are attached.

<u>Tracks excluded from analysis</u>: Tracks reported as "not included" represent tracks which were not correctly reported by the fieldworker (e.g. pad width = 20 cm), or any tracks that for any reason were not used in determining the number of tigers on your area.

<u>Size of each track for analysis</u>: If a fieldworker reported a range of values for a track size (for instance 10,0-10,5 cm), then for analysis the average of the range should be used.

<u>What track size category to use for differentiating individuals</u>: During the 1996 tiger survey, coordinators agreed that tracks that differ over 1cm in size are considered to belong to different individuals. Since then, information from Yudin (in press) and Salkina and Kerley (in prep.) suggest that with different substrates and different counters, differences of up to 2 cm are possible. Salkina and Kerley propose that tracks whose size vary by < 1.5 cm should be considered made by the same animal. We will use two criteria, one to maintain consistency with previous surveys, and one to represent existing knowledge of errors in measuring track size:

a) For the relaxed set of criteria, tracks which are separated in size by less than or equal to 1 cm are considered to be potentially from the same animal.

b) For the strict set of criteria, tracks which are separated in size by less than or equal to 1.5 cm are considered to be potentially from the same animal.

Classification of tracks: For separation of tracks in sex-age categories, we will use the following gradation in track size (from Yudin, in press):

Table 1. Track classes based on size of front pad of Amur tigers

Track class	Pad width (cm)	Sex-age class
1	8,5	Cubs less than 9 months
2	8,5-10,5	Adult females, sub-adult females (> 1 year), and males < 16 months
3	>10,5	Sub-adult and adult males

Note: Sex-age class #2 is the most difficult to differentiate. However, the following points will help:

1. Cubs less than 12 months old are normally in association with their mother, or there are at least tracks of the mother coming into and out of areas where cubs are. Additionally, cubs less than 12 months old are usually with other members of the litter.

2. Cubs between 12 and 18 months of age will often be without their mother, but are often in association with other members of the litter.

Sex-age classes for analysis: We recommend classifying tracks into the following groups, based on size of tracks and association with other tigers:

1. Cubs: All tracks are less than 8.5 cm.

2. Female with cubs: At least one set of tracks is 8.5-10.5 cm, with an additional set measuring 5-10.5 cm. In the situation where a single young male cub (> 15 months) is still traveling with mother, it will be difficult to delineate between a female with one male cub, and a female with an adult male consort. Repeated observations of such a pair for more than a week would determine whether a pair is indeed a female with a single male cub. All other sets of tracks (two or more animals) should be easily identified as a female with cubs. Tracks of cubs with no trace of a mother can occur, but are relatively rare (unless there is fresh snow or the mother has been killed). Females with cubs, however, often hunt and travel without their cubs, so a female with cubs can often be registered as a single individual as well.

3. Adult and sub-adult males (>16 months) males: all tracks > 10.5 cm, except those that are in constant association with one female (see above).

4. Sub-adult and adult females: most sub-adult males will be in association with either their mother or a sibling. Therefore, the majority of tracks of lone tigers with a pad size of 8.5-10.5 will be adult and sub-adult females.

5. Unknown category.

Table 2. Sex-age classes of Amur tigers based on size of front pad.

Sex-age class	Pad width (cm)	Criteria
Cubs	8,5	Track size
Female with cubs	8,5-10,5	1. Any group with at least 1 track 8.5-10.5, and others less than 8.5; 2. Any group of more than two tigers; 3. If one track > 10.5, and group size = 2, but tracks consistently together over winter period
Male	> 10.5	Track size
Female	8.5 -10,5	Lone track consistently reported in one area
Unknown	> 8.4	Tracks for some reason are not consistent with above groups

<u>Barriers that separate tracks as separate individuals</u>:

1. Elevation: Due to deep snow conditions, it is assumed that elevations greater than 700 m will be effective barriers to travel for tigers. Therefore, tracks of the same size but which are separated by such elevation gradients, will be considered separate animals. If snow depth is particularly low in a year or in particular region, then this geographic barrier will not exist.

2. Open fields: Open, unforested lands (generally free of vegetation, e.g., plowed fields) greater than 3 km wide and 10 km long represent effective barriers to travel for tigers, irrespective of snow depth.

3. Settlements: We assume that tigers will not travel THROUGH settlements, but usually travel along their edge and around them. Therefore, distance between two tracks, if there is a settlement between them, is the distance it takes to travel around the settlement.

4. Age of tracks: If tracks were identified by field workers to have been created on the same day, there is some likely distance a single tiger is likely to travel to create two or more sets of tracks. Therefore, the freshness of tracks is an important variable useful in distinguishing individuals within a specific region. However, as tracks get older, the precision with which their age can be determined diminishes greatly. It is generally believed that tracks less than 24 hours old can be reliably identified. Tracks 1-3 days old can also be identified, but accuracy already diminishes at this age. Based on likely travel distances, tracks older than 4 days are of less significance because most tigers have the capacity to travel across their entire home range in that period, making distances greater than that walked in that amount of time unimportant. It was assumed, in the criteria worked out for the 1996 survey, that an error of 1 day is possible in calculating track age between 1 and 4 days.

5. Average daily travel distance and likely maximum distance between tracks of a single individual: Determining whether the distance separating tracks is sufficient to consider them made by separate individuals will usually be determined by the likely daily travel distance and the diameter of home ranges of resident tigers. Yudakov and Nikolaev reported that adult male tigers travel, on average, 9.6 km (maximum = 41 km) per day when not at a kill, and that adult female tigers travel on average, 7 km (maximum = 22 km) per day. This is the actual distance traveled. Linear distance between two sets of

tracks, which is the variable that will be assessed in the track data, will be less than actual travel distance.

In *Sikhote-Alin*, locations of radio-collared tigers on sequential days were analyzed to provide an indication of the average, median, and quartile estimates of daily distances traveled by radio-collared tigers on sequential days. Separate summaries are provided for females, females with cubs, and males. These data demonstrate that when on kills, animals travel very short distances only. When not on kills, females with cubs travel slightly shorter distances that females without cubs, and males travel the greatest distances (Table 5).

Table 5. Daily straight-line distance traveled by tigers, based on radio locations of individual tigers on consecutive days. Data from the Russian-American Siberian Tiger Project, 1992-2002.

					Straight-line distance between locations on two consecutive days (m)							
Sex	Kill	Cubs	# tigers	n	Means	SD	20% quartile	25% quartile	Median	75% quartile	80% quartile
Females	on kill	cubs	9	117	425	627	0	0	219	603	846
	on kill	no cubs	13	191	244	394	0	0	0	382	537
	not on kill	cubs	9	731	3236	3321	526	744	2113	4717	5468
	not on kill	no cubs	13	582	5015	3931	1669	1925	4053	7078	8324
Males	on kill		7	50	332	656	0	0	0	373	523
	not on kill		7	163	6699	4960	2061	2672	5573	9660	10786

Criteria developed for the 1996 survey employed 5 km and 7.5 km as the daily travel distance of females and males, respectively. Use of a mean would include only half of the daily travel distances for any sex-age class. To be more inclusive, we recommend using the 75% quartile, which would include, on average 75% of all daily travel distances for a sex-age class. Using the 75% quartile as a base, daily average travel distance would be 4.7 km for females with cubs, 7.1 km for females without cubs, and 9.6 km for males.

6. Maximum likely distance between tracks of one individual: As differences in ages of adjacent, similar-sized tracks increases, the possibility of those tracks being made by a single individual increases as the probable distance a tiger could move over larger periods of time increases. However, for resident tigers that typically confine their movements to well-defined home ranges, the likely distance between two tracks that could have been made by one individual reaches a threshold that is dependent on the size (diameter) of an animal's home range. For female tigers radio-collared in and near Sikhote-Alin Zapovednik the average home range size of 12 adult females was 440 km^2 (minimum convex polygon) and 1,450 km^2 for three males (Goodrich et al. in prep). Assuming that home ranges can be represented in the abstract by a circle, the diameter of these home ranges would average approximately 24 km for females, and 43 km for males. Yudakov and Nikolaev (1986) reported maximum home range diameters of 35 and 27 km for two females, and 45 km for a male. Our estimate from Sikhote-Alin is an abstraction, and is no doubt lower than the maximum diameter of any single home range, which are not in actuality circular. Based on these measurements, no matter how many days separate the age of neighboring tracks, if those tracks were created by animals with the same size

track, but are greater than 25 km apart for females, or 43 km for males, there is a high probability that they were created by different animals. However, when we measured the widest diameter of each home range, the potential maximum distance between two tracks of the same animal increases slightly (Table 4).

Table 4. Home range diameters of Amur tigers (*Sikhote-Alin Zapovednik*)

Sex-age class	Average home range diameter (km)	Maximum home range diameter (km)
Adult male	43	54
Adult female	24	29
Adult female with cubs	24	29

7. Distinguishing individuals based on track age and distance between tracks: To distinguish between individual tigers, it is necessary to assess the distance between tracks in relation to their age. Tigers with track sizes in the same size category will be considered to be different if the distance between them is greater than the estimated travel distance for the period of time separating them, for tracks separating in time by three or less days. For tracks separated by at least four days, tigers can potentially travel across their entire home range, and therefore the maximum distance (diameter of home ranges) should be used.

8. Hard and soft criteria: In assessing distances between tracks, two sets of criteria were developed, "relaxed" and "strict." Strict criteria, when applied to a set of track data, should provide a more conservative estimate of tiger abundance, while "relaxed" data will provide a larger estimate of abundance. Development and application of these two sets of criteria are necessitated by the great heterogeneity of data, and the difficulty in obtaining an objective assessment of the many factors influencing the census results. It is possible, for example, that a single set of criteria for both high and low density populations of tigers cannot be established. The "hard" criteria may be considered a conservative means of determining the guaranteed minimum number of tigers. In both sets of criteria the average values of male and female track groups are used for animal of undetermined sex. In situations where tracks that fall into different size groups are being compared (i.e., 10.3 and 10.7 size tracks), criteria for the larger size class should be applied.

9. Hard (minimum) criteria: In developing the "hard" criteria, the following conditions are used:

    - If the dates of passage of two tracks coincide (i.e., zero difference in time tracks were laid down), tracks can be considered created by one animal if the distance between tracks is less than or equal to the 24-hour travel distance for that size class.

    - An additional 24-hour travel distance is added to account for tracks created on different days (e.g. if tracks were created two days apart, the distance criteria would be three 24-hour movements).

    - Taking into consideration the high possibility of errors in determining the dates when tracks were created (and often the inaccuracy of plotting location of tracks on maps), the 24-hour travel distance used in distinguishing individuals should be double the actual observed average travel distance of tigers.

These criteria are shown in the table below for up to three successive travel days (including where there is no difference in the dates the tracks were made), where the smaller value corresponds to the limit above which tracks are considered possibly made by different individuals, and the upper value corresponds to the limit above which tracks are considered definitely made by separate individual tigers. Values are calculated to the nearest 0.5 km.

Table 5. “Hard” criteria for determining if two tracks (which are no more than 1.5 cm difference in size) were made by the same individual.

Size class (size of front pad, cm)	Difference in age of tracks (days)					
	0	1	2	3	4	≥5
8.5-10.5 (female with cubs)	5	10	15	20	24	24
8.5-10.5 (female without cubs)	7	14	21	24	24	24
>10,5	10	20	30	40	45	45

10. Soft criteria: In developing the “soft” criteria, the following conditions are used:

- If the dates of passage of two tracks coincide (i.e., zero difference regarding the time the tracks were laid down), half the estimated daily travel distance is used to determine whether tracks are considered representative of one individual tiger.
- For tracks that are separated by one day, the daily travel distance used will be equal to 1.5 travel days; for two-day differences it will be 2.5 travel days, and for three-day differences it will be a 3.5 line distance.
- The quantities used to separate tracks based on 24-hour linear distances are not doubled.

Table 6. “Soft” criteria for determining if two tracks (which are no more than 1 cm different in size) were made by the same individual.

Size class (size of front pad, cm)	Difference in age of tracks (days)					
	0	1	2	3	4	≥5
8.5-10.5 (female with cubs)	2.5	7.5	12.5	17.5	23.5	24
8.5-10.5 (female without cubs)	3.5	10.5	17.5	24	24	24
>10,5	5	15	25	35	45	45

11. “Questionable” individuals: Sets of tracks that are difficult to distinguish due to specific problems with the original material (i.e., contradictions or inaccuracies of documents) should be identified as tigers of doubtful identity, and included in this category in the summary tables.

12. Coordination with adjacent territories. Each coordinator is responsible to meet with coordinators from adjacent regions to review data and determine whether individual animals could be using both territories. In those cases where it is agreed that an animal crosses boundaries between coordinators, those two (or more) coordinators must agree among themselves who will report the animal, so there are not duplicate counts.